ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ
АКАДЕМИЯСЫ» РҚБ

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»

NEWS

OF THE NATIONAL ACADEMY
OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

1 (469)

JANUARY – FEBRUARY 2025

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

БАС РЕДАКТОР

ЖҰРЫНОВ Мұрат Жұрынұлы, химия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, РҚБ «Қазақстан Республикасы Ұлттық Ғылым академиясының» президенті, АҚ «Д.В. Сокольский атындағы отын, катализ және электрохимия институтының» бас директоры (Алматы, Қазақстан), https://www.scopus.com/authid/detail.uri?authorId=6602177960, https://www.webofscience.com/wos/author/record/2017489

БАС РЕДАКТОРДЫҢ ОРЫНБАСАРЫ:

ӘБСАДЫҚОВ Бақыт Нәрікбайұлы, техника ғылымдарының докторы, профессор, ҚР ҰҒА академигі, А.Б. Бектұров атындағы Химия ғылымдары институты, (Алматы, Қазақстан), https://www.scopus.com/authid/detail.uri?authorId=6504694468, https://www.webofscience.com/wos/author/record/2411827

РЕДАКЦИЯ АЛҚАСЫ:

ӘБСӘМЕТОВ Мәліс Құдысұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, У.М. Ахмедсафин атындағы Гидрогеология және геоэкология институтының директоры, (Алматы, Қазақстан), https://www.scopus.com/authid/detail.uri?authorId=56955769200, https://www.webofscience.com/wos/author/record/1937883

ЖОЛТАЕВ Герой Жолтайұлы, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА құрметті академигі, (Алматы, Қазақстан), https://www.scopus.com/authid/detail.uri?authorId=57112610200, https://www.webofscience.com/wos/author/record/1939201

СНОУ Дэниел, PhD, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры, (Небраска штаты, АҚШ), https://www.scopus.com/authid/detail.uri?authorId=7103259215, https://www.webofscience.com/wos/author/record/1429613

ЗЕЛЬТМАНН Раймар, PhD, Жер туралы ғылымдар бөлімінің петрология және пайдалы қазбалар кен орындары саласындағы зерттеулерінің жетекшісі, Табиғи тарих мұражайы, (Лондон, Ұлыбритания), https://www.scopus.com/authid/detail.uri?authorId=55883084800, https://www.webofscience.com/wos/author/record/1048681

ПАНФИЛОВ Михаил Борисович, техника ғылымдарының докторы, Нанси университетінің профессоры, (Нанси, Франция), https://www.scopus.com/authid/detail.uri?authorId=7003436752, https://www.webofscience.com/wos/author/record/1230499

ШЕН Пин, PhD, Қытай геологиялық қоғамының Тау-кен геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі, (Бейжің, Қытай), https://www.scopus.com/authid/detail.uri?authorId=57202873965, https://www.webofscience.com/wos/author/record/1753209

ФИШЕР Аксель, қауымдастырылған профессор, PhD, Дрезден техникалық университеті, (Дрезден, Берлин), https://www.scopus.com/authid/detail.uri?authorId=35738572100, https://www.webofscience.com/wos/author/record/2085986

АГАБЕКОВ Владимир Енокович, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры, (Минск, Беларусь), https://www.scopus.com/authid/detail.uri?authorId=7004624845

КАТАЛИН Стефан, PhD, қауымдастырылған профессор, Техникалық университеті (Дрезден, Германия), https://www.scopus.com/authid/detail.uri?authorId=35203904500, https://www.webofscience.com/wos/author/record/1309251

САҒЫНТАЕВ Жанай, PhD, қауымдастырылған профессор, Назарбаев университеті (Астана, Қазақстан), https://www.scopus.com/authid/detail.uri?authorId=57204467637, https://www.webofscience.com/wos/author/record/907886

ФРАТТИНИ Паоло, PhD, қауымдастырылған профессор, Бикокк Милан университеті, (Милан, Италия), https://www.scopus.com/authid/detail.uri?authorId=56538922400

НҰРПЕЙІСОВА Маржан Байсанқызы – Техника ғылымдарының докторы, Қ.И. Сәтбаев атындағы Қазақұлттықзерттеутехникалықуниверситетініңпрофессоры,(Алматы,Қазақстан),https://www.scopus.com/authid/detail.uri?authorId=57202218883, https://www.webofscience.com/wos/author/record/AAD-1173-2019

РАТОВ Боранбай Тойбасарұлы, техника ғылымдарының докторы, профессор, «Геофизика және сейсмология» кафедрасының меңгерушісі, Қ.И. Сәтбаев атындағы Қазақ ұлттық зерттеу техникалық университеті, (Алматы, Қазақстан), https://www.scopus.com/authid/detail.uri?authorId=55927684100, https://www.webofscience.com/wos/author/record/1993614

РОННИ Берндтссон, Лунд университетінің Таяу Шығысты перспективалы зерттеу орталығының профессоры, Лунд университетінің толық курсты профессоры, (Швеция), https://www.scopus.com/authid/detail.uri?authorId=7005388716, https://www.webofscience.com/wos/author/record/1324908

МИРЛАС Владимир, Ариэль университетінің Химиялық инженерия факультеті және Шығыс ғылыми-зерттеу орталығы, (Израиль), https://www.scopus.com/authid/detail.uri?authorId=8610969300, https://www.webofscience.com/wos/author/record/53680261

«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *Геология, гидрогеология, география, тау-кен ісі, мұнай, газ және металдардың химиялық технологиялары*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

© «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ, 2025

ГЛАВНЫЙ РЕДАКТОР

ЖУРИНОВ Мурат Журинович, доктор химических наук, профессор, академик НАН РК, президент РОО Национальной академии наук Республики Казахстан, генеральный директор АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского» (Алматы, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=6602177960, https://www.webofscience.com/wos/author/record/2017489

ЗАМЕСТИТЕЛЬ ГЛАВНОГО РЕДАКТОРА

АБСАДЫКОВ Бахыт Нарикбаевич, доктор технических наук, профессор, академик НАН РК, Институт химических наук им. А.Б. Бектурова (Алматы, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=6504694468, https://www.webofscience.com/wos/author/record/2411827

РЕДАКЦИОННАЯ КОЛЛЕГИЯ:

АБСАМЕТОВ Малис Кудысович, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=56955769200, https://www.webofscience.com/wos/author/record/1937883

ЖОЛТАЕВ Герой Жолтаевич, доктор геологоминералогических наук, профессор, почетный академик НАН РК (Алматы, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=57112610200, https://www.webofscience.com/wos/author/record/1939201

СНОУ Дэниел, PhD, ассоциированный профессор, директор Лаборатории водных наук Университета Небраски (штат Небраска, США), https://www.scopus.com/authid/detail.uri?authorId=7103259215, https://www.webofscience.com/wos/author/record/1429613

ЗЕЛЬТМАНН Раймар, PhD, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Англия), https://www.scopus.com/authid/detail.uri?authorId=55883084800,https://www.webofscience.com/wos/author/record/1048681

ПАНФИЛОВ Михаил Борисович, доктор технических наук, профессор Университета Нанси (Нанси, Франция), https://www.scopus.com/authid/detail.uri?authorId=7003436752, https://www.webofscience.com/wos/author/record/1230499

ШЕН Пин, PhD, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай), https://www.scopus.com/authid/detail.uri?authorId=57202873965, https://www.webofscience.com/wos/author/record/1753209

ФИШЕР Аксель, ассоциированный профессор, PhD, технический университет Дрезден (Дрезден, Берлин), https://www.scopus.com/authid/detail.uri?authorId=35738572100, https://www.webofscience.com/wos/author/record/2085986

АГАБЕКОВ Владимир Енокович, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь), https://www.scopus.com/authid/detail.uri?authorId=7004624845

КАТАЛИН Стефан, PhD, ассоциированный профессор, Технический университет (Дрезден, Германия), https://www.scopus.com/authid/detail.uri?authorId=35203904500, https://www.webofscience.com/wos/author/record/1309251

САГИНТАЕВ Жанай, PhD, ассоциированный профессор, Назарбаев университет (Астана, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=57204467637 , https://www.webofscience.com/wos/author/record/907886

ФРАТТИНИ Паоло, PhD, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия), https://www.scopus.com/authid/detail.uri?authorId=56538922400 **НУРПЕИСОВА Маржан Байсановна** – доктор технических наук, профессор Казахского Национального исследовательского технического университета им. К.И. Сатпаева, (Алматы, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=57202218883, https://www.webofscience.com/wos/author/record/AAD-1173-2019

РАТОВ Боранбай Тойбасарович, доктор технических наук, профессор, заведующий кафедрой «Геофизика и сейсмология», Казахский Национальный исследовательский технический университет им. К.И. Сатпаева, (Алматы, Казахстан), https://www.scopus.com/authid/detail.uri?authorId=55927684100, https://www.webofscience.com/wos/author/record/1993614

РОННИ Берндтссон, Профессор Центра перспективных ближневосточных исследований Лундского университета, профессор (полный курс) Лундского университета, (Швеция), https://www.scopus.com/authid/detail.uri?authorId=7005388716 , https://www.webofscience.com/wos/author/record/1324908

МИРЛАС Владимир, Факультет химической инженерии и Восточный научно-исследовательский центр, Университет Ариэля, (Израиль), https://www.scopus.com/authid/detail.uri?authorId=8610969300, https://www.webofscience.com/wos/author/record/53680261

«Известия РОО «НАН РК». Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, гидрогеология, география, горное дело и химические технологии нефти, газа и металлов*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

© РОО «Национальная академия наук Республики Казахстан», 2025

EDITOR-IN-CHIEF

ZHURINOV Murat Zhurinovich , Doctor of Chemical Sciences, Professor, Academician of NAS RK, President of National Academy of Sciences of the Republic of Kazakhstan, RPA, General Director of JSC " D.V. Sokolsky Institute of Fuel, Catalysis and Electrochemistry " (Almaty, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=6602177960, https://www.webofscience.com/wos/author/record/2017489

DEPUTY EDITOR-IN-CHIEF

ABSADIKOV Bakhyt Narikbaevich, Doctor of Technical Sciences, Professor, Academician of NAS RK, A.B. Bekturov Institute of Chemical Sciences (Almaty, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=6504694468, https://www.webofscience.com/wos/author/record/2411827

EDITORIAL BOARD:

ABSAMETOV Malis Kudysovich, (Deputy Editor-in-Chief), Doctor of Geological and Mineralogical Sciences, Professor, Academician of NAS RK, Director of the Akhmedsafin Institute of Hydrogeology and Geoecology (Almaty, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=56955769200, https://www.webofscience.com/wos/author/record/1937883

ZHOLTAEV Geroy Zholtaevich, Doctor of Geological and Mineralogical Sciences, Professor, Honorary Academician of NAS RK (Almaty, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=57112610200, https://www.webofscience.com/wos/author/record/1939201

SNOW Daniel, PhD, Associate Professor, Director, Aquatic Sciences Laboratory , University of Nebraska (Nebraska, USA), https://www.scopus.com/authid/detail.uri?authorId=7103259215, https://www.webofscience.com/wos/author/record/1429613

SELTMANN Reimar, PhD, Head of Petrology and Mineral Deposits Research in the Earth Sciences Department, Natural History Museum (London, England), https://www.scopus.com/authid/detail.uri?authorId=55883084800, https://www.webofscience.com/wos/author/record/1048681

PANFILOV Mikhail Borisovich, Doctor of Technical Sciences, Professor at the University of Nancy (Nancy, France), https://www.scopus.com/authid/detail.uri?authorId=7003436752, https://www.webofscience.com/wos/author/record/1230499

SHEN Ping, PhD, Deputy Director of the Mining Geology Committee of the Chinese Geological Society, Member of the American Association of Economic Geologists (Beijing, China), https://www.scopus.com/authid/detail.uri?authorId=57202873965 , https://www.webofscience.com/wos/author/record/1753209

FISCHER Axel, PhD, Associate Professor, Technical University of Dresden (Dresden, Berlin), https://www.scopus.com/authid/detail.uri?authorId=35738572100,https://www.webofscience.com/wos/author/record/2085986

AGABEKOV Vladimir Enokovich, Doctor of Chemical Sciences, Academician of NAS of Belarus, Honorary Director of the Institute of Chemistry of New Materials (Minsk, Belarus), https://www.scopus.com/authid/detail.uri?authorId=7004624845

CATALIN Stefan, PhD, Associate Professor, Technical University of Dresden, Germany, https://www.scopus.com/authid/detail.uri?authorId=35203904500, https://www.webofscience.com/wos/author/record/1309251

Jay Sagin, PhD, Associate Professor, Nazarbayev University (Astana, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=57204467637 , https://www.webofscience.com/wos/author/record/907886

FRATTINI Paolo, PhD, Associate Professor, University of Milano - Bicocca (Milan, Italy), https://www.scopus.com/authid/detail.uri?authorId=56538922400

NURPEISOVA Marzhan Baysanovna – Doctor of Technical Sciences, Professor of Satbayev University, (Almaty, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=57202218883, https://www.webofscience.com/wos/author/record/AAD-1173-2019

RATOV Boranbay Toybasarovich , Doctor of Technical Sciences, Professor, Head of the Department of Geophysics and Seismology, Satbayev University (Almaty, Kazakhstan), https://www.scopus.com/authid/detail.uri?authorId=55927684100, https://www.webofscience.com/wos/author/record/1993614

RONNY Berndtsson, Professor at the Center of Promising Middle Eastern Research, Lund University (Sweden), https://www.scopus.com/authid/detail.uri?authorId=7005388716 , https://www.webofscience.com/wos/author/record/1324908

MIRLAS Vladimir, Faculty chemical engineering and Oriental research center, Ariel University, (Israel), https://www.scopus.com/authid/detail.uri?authorId=8610969300 , https://www.webofscience.com/wos/author/record/53680261

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, hydrogeology, geography, mining and chemical technologies of oil, gas and metals*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

© National Academy of Sciences of the Republic of Kazakhstan, 2025

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 1. Number 469 (2025), 169–181

https://doi.org/10.32014/2025.2518-170X.483

UDC 628.16:66.046.5

Ya.N. Parshakova, A.O. Ivantsov, 2025.
Institute of Continuous Media Mechanics, Ural Branch of the Russian Academy of Sciences, Perm, Russia.
E-mail: parshakova@icmm.ru

DEVELOPMENT OF A METHOD OF WATER TREATMENT IN THE PROCESS OF PREPARATION FOR UTILISATION OF PRODUCTION WASTE

Yanina Nikolaevna Parshakova – Senior Researcher, Institute of Continuous Media Mechanics, Ural Branch of the Russian Academy of Sciences, Perm, Russia, e-mail: parshakova@icmm.ru, ORCID: https://orcid.org/0000-0002-0234-3854;
Andrey Olegovich Ivantsov – Researcher, Institute of Continuous Media Mechanics, Ural Branch of the Russian Academy of Sciences, Perm, Russia, e-mail: aivantsov@gmail.com, ORCID: https://orcid.org/0000-0002-5703-3247.

Abstract. This paper considers the problem of utilisation of excess brines generated during potash ore processing at the Verkhne-Kamskoe deposit. The traditional method - discharge into water bodies - is not efficient enough and does not take into account changes in the hydrological regime. It is proposed to use filtration columns to purify brines before disposal, which requires efficient calculation of the purification process. To model the filtration process, the concept of mobile/immobile medium (MIM approach) is used to account for the interaction of impurity particles with the solid skeleton of the medium. This two-phase kinetic diffusion model incorporates the impurity adsorption and desorption parameters experimentally determined and verified within the study. Numerical modelling was carried out in a three-dimensional formulation taking into account the industrial dimensions of the filtration column and unsteady filtration conditions. The calculations are based on the solution of the system of equations describing impurity transport and fluid filtration in a porous medium, taking into account Darcy's law and the Kozeny-Karman equation for permeability. The model takes into account the change of solution density depending on salt concentration. The results of numerical modelling show the dynamics of change of impurity concentration in time and space, as well as deposition of impurity on the skeleton of porous medium. The analysis of the obtained results allows to estimate the filtration efficiency and to determine the necessity of filter washing. It is established that the sand filter can effectively reduce the concentration of salts in brines, while the need for washing is determined when the critical level of contamination of the filter material is reached. The conclusions of the work confirm the promising application of filtration columns for purification of excessive brines of potash production and allow optimising the process of waste disposal, reducing the environmental load on water bodies. The results obtained can be used to design and optimise industrial water treatment systems for potash production.

Keywords: water treatment, filtration column, highly concentrated brine, porous medium, Brinkman model

Funding Statement: *The research was supported by a grant from the Russian Science Foundation Project No. 20-11-20125, https://rscf.ru/en/project/20-11-20125/.*

Я.Н. Паршакова, А.О. Иванцов, 2025.
Үздіксіз медиа механика институты, РҒА, Орал Филиалы, Пермь, Ресей.
E-mail: parshakova@icmm.ru

ӨНДІРІСТІК ҚАЛДЫҚТАРДЫ КӘДЕГЕ ЖАРАТУҒА ДАЙЫНДАУ ПРОЦЕСІНДЕ СУДЫ ТАЗАРТУ ӘДІСІН ЖАСАУ

Янина Николаевна Паршакова – аға ғылыми қызметкер, Үздіксіз медиа механика институты, РҒА, Пермь, Ресей, e-mail: parshakova@icmm.ru, ORCID: https://orcid.org/0000-0002-0234-3854;
Андрей Олегович Иванцов – ғылыми қызметкер, Үздіксіз медиа механика институты, РҒА, Пермь, Ресей, e-mail: aivantsov@gmail.com, ORCID: https://orcid.org/0000-0002-5703-3247.

Аннотация. Жұмыста Жоғарғы Кама кен орнында калий кендерін байыту кезінде пайда болатын артық тұзды ерітінділерді жою мәселесі қарастырылады. Дәстүрлі су объектілеріне төгу әдісі жеткілікті дәрежеде тиімді емес және гидрологиялық режимнің өзгеруін ескермейді. Кәдеге жаратпас бұрын тұзды ерітінділерді тазарту үшін сүзгі бағандарын пайдалану ұсынылады, бұл тазалау процесін тиімді есептеуді қажет етеді. Сүзу процесін модельдеу үшін қоспа бөлшектерінің ортаның қатты қаңқасымен әрекеттесуін ескеретін мобильді/мобильді емес орта (MIM тәсілі) тұжырымдамасы қолданылады. Бұл екі фазалы кинетикалық диффузия моделі қоспаның адсорбциясы мен десорбциясы параметрлерін қамтиды, зерттеу шеңберінде эксперименталды түрде анықталған және тексерілген. Сандық модельдеу сүзгі бағанының өнеркәсіптік өлшемдерін және стационарлық емес сүзу жағдайларын ескере отырып, үш өлшемді өндірісте жүргізілді. Есептеулер Дарси Заңын және өткізгіштік үшін Козени-қалта теңдеуін ескере отырып, кеуекті ортадағы қоспаның тасымалдануын және сұйықтықтың сүзілуін сипаттайтын теңдеулер жүйесін шешуге негізделген. Модель тұз концентрациясына байланысты ерітіндінің тығыздығының өзгеруін ескереді. Сандық модельдеу нәтижелері уақыт пен кеңістіктегі қоспа концентрациясының өзгеру динамикасын, сондай-ақ кеуекті ортаның қаңқасында қоспаның тұнбасын көрсетеді. Алынған нәтижелерді талдау сүзудің тиімділігін бағалауға және сүзгіні жуу қажеттілігін анықтауға мүмкіндік береді. Құм сүзгісі тұзды ерітінділердегі тұздардың концентрациясын тиімді төмендететіні анықталды, жуу қажеттілігі сүзгі материалының ластануының маңызды деңгейіне жеткенде анықталады. Жұмыстың қорытындылары калий өндірісінің артық тұзды ерітінділерін тазарту үшін сүзгі бағандарын қолдану перспективасын растайды және су объектілеріне экологиялық жүктемені азайта отырып, қалдықтарды жою процесін оңтайландыруға мүмкіндік береді. Алынған нәтижелер калий өндірісі жағдайында өнеркәсіптік су тазарту жүйелерін жобалау және оңтайландыру үшін пайдаланылуы мүмкін.

Түйін сөздер: суды тазарту, сүзгі бағанасы, жоғары концентрацияланған тұзды ерітінді, кеуекті орта, бринкман моделі.

Я.Н. Паршакова, А.О. Иванцов, 2025.
Институт механики сплошных сред УрО РАН, Пермь, Россия
E-mail: parshakova@icmm.ru, adm@icmm.ru

РАЗРАБОТКА МЕТОДА ОЧИСТКИ ВОДЫ В ПРОЦЕССЕ ПРЕПОДГОТОВКИ ДЛЯ УТИЛИЗАЦИИ ОТХОДОВ ПРОИЗВОДСТВА

Янина Николаевна Паршакова – старший научный сотрудник, Институт механики сплошных сред УрО РАН, Пермь, Россия, e-mail: parshakova@icmm.ru, ORCID: https://orcid.org/0000-0002-0234-3854;
Андрей Олегович Иванцов – научный сотрудник, Институт механики сплошных сред УрО РАН, Пермь, Россия, e-mail: aivantsov@gmail.com, ORCID: https://orcid.org/0000-0002-5703-3247.

Аннотация. В работе рассматривается проблема утилизации избыточных рассолов, образующихся при обогащении калийных руд на Верхне-Камском месторождении. Традиционный метод – сброс в водоемы – недостаточно эффективен и не учитывает изменения гидрологического режима. Предлагается использовать фильтрационные колонны для очистки рассолов перед утилизацией, что требует эффективного расчета процесса очистки. Для моделирования процесса фильтрации используется концепция мобильно/немобильной среды (MIM-подход), учитывающая взаимодействие частиц примеси с твердым скелетом среды. Эта двухфазная кинетическая модель диффузии включает параметры адсорбции и десорбции примеси, экспериментально определенные и верифицированные в рамках исследования. Численное моделирование проводилось в трехмерной постановке с учетом промышленных размеров фильтрационной колонны и нестационарных условий фильтрации. Расчеты основаны на решении системы уравнений, описывающих транспорт примеси и фильтрацию жидкости в пористой среде, с учетом закона Дарси и уравнения Козени-Кармана для проницаемости. Модель учитывает изменение плотности раствора в зависимости от концентрации соли. Результаты численного моделирования показывают динамику изменения концентрации примеси во времени и пространстве, а также осаждения примеси на скелете пористой среды. Анализ полученных результатов позволяет оценить эффективность фильтрации и определить необходимость промывки фильтра. Установлено, что песочный фильтр может эффективно снижать концентрацию солей в рассолах, при этом необходимость промывки определяется по достижении критического уровня загрязнения фильтрующего материала. Выводы работы подтверждают перспективность применения фильтрационных колонн для очистки избыточных рассолов калийного производства и позволяют оптимизировать процесс утилизации отходов, снижая экологическую нагрузку на водоемы. Полученные результаты могут быть использованы для проектирования и оптимизации промышленных систем водоочистки в условиях калийного производства.

Ключевые слова: очистка воды, фильтрационная колонна, высококонцентрированный рассол, пористая среда, модель Бринкмана

Introduction. The largest potash and magnesium salt deposit is the Verkhne-Kamskoye (VKMKMS). The resulting ore is a mixture of potassium chloride, magnesium chloride and sodium chloride, with potassium chloride acting as the main ‘useful component’. Currently, the beneficiation of potash ores is generally carried out in the aqueous phase. In the aqueous phase beneficiation process, approximately 1 m3 of water is required to dissolve one tonne of ore, resulting in the need to remove and dispose of excess brines.

Despite advances in beneficiation and wastewater treatment technologies, to date, in the VKMKMS area and in Europe, virtually the only method of disposal of excess brine is discharge to surface water bodies. Given that the hydrological and hydrochemical regimes of water bodies change significantly throughout the year, while the production processes that create wastewater remain relatively stable, it is important to synchronise these processes to reduce loads during periods of water shortage (Kobylkin, et. al., 2022; Batukhtin, et. al., 2020; Golik, et. al., 2023; Cherkasova, et. al., 2022). This synchronisation can be achieved through the use of filtration columns that allow wastewater to be treated in a manner that meets regulatory water quality requirements for disposal to surface water bodies. In the implementation of this scheme, an efficient calculation of excess brine treatment processes becomes a central issue (Pashkov, et. al., 2014; Malyukova, et. al., 2023).

Industrial water treatment and water purification is the process of removing impurities and contaminants from the initial composition of the medium. In order to obtain a liquid with specified quality parameters, complex systems of filters and treatment plants are used. Analysing the filtration process in order to find an effective way to control the water purification process when transporting a limited volume of impurity in a porous column is in demand, as it has wide application in industrial scale (Batukhtin, et. al., 2018; Golik, et. al., 2023; Klyuev, et. al., 2019). Quite a large number of works have been carried out in the framework of laboratory experiments and theoretical studies of systems characterised by laboratory scale (Pang, et al., 2004; Agaoglu, et. al., 2012).

When a fluid flows in an array of porous media, there is a problem of visualising the change in concentration of the solute dispersing in the carrier medium. Experiments on visualisation of dispersion of dissolved substances within the laboratory scale are performed on transparent model porous media of different morphology. In this way, longitudinal and transverse dispersion coefficients are evaluated as a function of fluid flow rate and appropriate dispersion regimes for solute dispersion are determined (Gomez, et. al., 2010).

Typically, impurity transport is described by jointly solving the filtration equations, in the framework of the classical Darcy model, and diffusion in the Fickian approximation. However, the characteristic times of impurity removal in such a model differ from the predicted ones by several orders of magnitude. For a more correct description of the process, the concept of mobile/immobile medium (MIM approach) was proposed (Maryshev, et. al., 2023). This concept takes into account the interaction (adhesion/ detachment) of impurity particles with the solid skeleton of the medium and is based on the two-phase kinetic model of diffusion. This approach assumes the presence of two phases of impurity: settled (adsorbed) impurity and free impurity drifting with the flow. In this paper, all the coefficients of the MIM model are experimentally and theoretically determined and verified.

Several researchers have conducted laboratory experiments on contaminant transport in sand columns (Nield, Bejan, 2017; Rolle, et al., 2009; Qian, et al., 2015). In (Nield, Bejan, 2017), the authors investigated the flow and mixing processes of variable density waters in porous media in laboratory reservoir models and concluded that density variations can create complex flow and mixing patterns. Rolle et al. (Rolle, et al., 2009) performed numerical simulations of laboratory experiments using both conservative and reactive tracers under transient flow conditions in porous media and found that the numerical results nearly matched the measured concentrations and that transient flow enhanced lateral mixing and mixing-controlled reactions. In (Qian, et al., 2015) presented a study on the transport dynamics of sodium chloride and the food colourant brilliant blue FCF through a column with homogeneous silica sand and found that sodium chloride less behaves in an excellent manner and is a non-passive impurity characterised by complex convective modes.

However, previous work on solute transport through porous aquifers has been carried out for laboratory installations. Such studies have not been carried out for industrial plants, which are characterised by dimensions of the order of ten metres, in combination with the changing characteristics of the porous media due to pore plugging (Kulikova et. al., 2024; Bosikov, et. al., 2023; Yaitskaya, et. al., 2024). Thus, additional studies are needed to fully understand the behaviour of high concentration water flow and solute transport with changing porous skeleton characteristics. Since a visualised study of the processes under industrial conditions is not possible, numerical simulations of solute transport (which are continuously pumped) are carried out within the scope of the present work under unsteady conditions in a homogeneous porous media column.

Numerical modelling of sand filter operation is carried out within the framework of the present work in order to assess the possibility of its application for reduction of salt concentration in excessive brines of potash production. The calculations are based on the MIM model of filtration developed in (Maryshev, et. al., 2023). The application of such filters will include a washing stage necessary to remove accumulated contaminants. Numerical modelling allows, among other things, to determine the frequency of washing and to calculate the filtration efficiency.

Problem Statement. Mechanical treatment of water is necessary to meet regulatory standards for turbidity, transparency and colour, which is due to the presence of insoluble suspended particles such as sand, clay, silt, colloidal iron and silica, as well as pipeline rust, scale and other impurities in water. This method is the most common way of water treatment. To organise industrial water treatment, large-sized filters (Fig. 1), reaching heights of up to ten metres, are used.

Fig. 1. Example of an industrial mechanical filtration filter. Vertical filtration column

Methods. To describe the equations of impurity transport, we consider a small physical volume of porous medium, *V*. Impurity transport is described on the basis of conservation laws, and it is assumed that filtration flows of the considered mixture completely fill the pore space. It is assumed that the internal structure of the filter prevents the development of instabilities of filtration flows, in particular the Rayleigh-Taylor instability. In this case, concentration convection of brine in the porous medium can be neglected.

The part of the space not occupied by the skeleton of the porous medium is called the pore space, V_0. Following (Maryshev, Khabin, Evgrafova, 2023), we will assume that part of the pore volume is filled by the carrier fluid and part by the impurity. The analysis in (Maryshev, Khabin, Evgrafova, 2023) shows that part of the impurity can be deposited on the walls of the skeleton of the porous medium. In this case, the pore volume will be divided between three components: the volume of the carrying fluid V_l, the volume occupied by the impurity deposited on the pore walls V_i and the volume of free impurity carried by the flow of the carrying fluid V_m. Thus, in the framework of the considered model $V_0 = V_l + V_m + V_i$. It is convenient to introduce a value characterising the volume of pores available for filtration flows: $V_p = V_l + V_m$. Let us divide the expression $V_0 = V_p + V_i$ by the total volume of the medium V and write

$\phi = \phi_0 - q$. 12* MERGEFORMAT ()

where $\phi_0 = V_0 / V$ is the porosity of the medium without impurity, $\phi = V_p / V$ is the porosity of the medium taking into account the volume of settled (adsorbed) impurity, $q = V_i / V$ determines the volume concentration of the settled impurity.

Let us define the volume concentration of the mobile part of the impurity as $c = V_m / V_p$. Then the law of conservation of impurity mass is written in the form:

$\frac{\partial}{\partial t}(\phi c + q) = -\mathrm{div}(\phi \mathbf{J}_c)$, 34* MERGEFORMAT ()

where the mass flux J_c can only be related to the mobile component of the impurity. According to Fick's law, the mass flux is calculated by the formula:

$\mathbf{J}_c = -D\nabla c + \mathbf{v}c$, 56* MERGEFORMAT ()

where **D** is coefficient effective diffusion, **v** is velocity of liquid in pore or pore velocity. The law of conservation of mass of liquid has the form:

$\frac{\partial(\phi(1-c))}{\partial t} = \mathrm{div}(\phi D \nabla (1-c) - \mathbf{v}(1-c))$. 78* MERGEFORMAT ()

Summarising these conservation laws, we obtain the incompressibility condition for filtration of the mixture:

$\mathrm{div}(\phi \mathbf{v}) = \mathrm{div}\,\mathbf{u} = 0,$ 910* MERGEFORMAT ()

where $\mathbf{u} = \mathbf{v}\phi$ is the filtration velocity. Thus, impurity transport can be described by the following system of equations:

$\frac{\partial}{\partial t}(\phi c + q) = \mathrm{div}(\phi D \nabla c - \mathbf{u}c);$

$\mathrm{div}\,\mathbf{u} = 0.$ 1112* MERGEFORMAT ()

The filtration flow is calculated using Darcy's law:

$$\frac{\eta}{\kappa(\phi)}\mathbf{u} = -\nabla p + \rho\mathbf{g},$$ 1314* MERGEFORMAT ()

where $\kappa(\phi)$ is permeability of the medium, η is dynamic viscosity coefficient, p is liquid density and g is gravitational acceleration. It is assumed that settling of particles on the pore walls occurs without significant change in the shape of the porous medium grain, in this case permeability can be described as a single-valued function of porosity. The most popular way of such description is given by the Kozeny-Karman equation.

$$\kappa(\phi) = \gamma\frac{\phi^3}{(1-\phi)^2},$$ 1516* MERGEFORMAT ()

where γ is the Kozeny-Karman parameter depending on the shape and distribution of the medium grains.

The transition of impurity from a mobile state to a stationary state will be described in the framework of the MIM approach (Maryshev, Khabin, Evgrafova, 2023):

$$\frac{\partial q}{\partial t} = \alpha(q_0 - q)c - \beta q,$$ 1718* MERGEFORMAT ()

where $\alpha = 29.6\ h^{-1}$, $\beta = 7.7\ h^{-1}$ are adsorption and desorption coefficients, respectively, $q_0 = 0.1$ is saturation concentration of the non-mobile component of the impurity. The values of the parameters are taken from (Maryshev, Khabin, Evgrafova, 2023).

Research results. Three-dimensional numerical simulation of flow was carried out in a columnar displacement array consisting of a porous medium characterised by industrial spatial dimensions of industrial samples. A case corresponding to the conditions where potassium salt is considered as a contaminant was considered. It is assumed that the vertical column is a desalination system, the operation of which results in saturation and clogging of the pores of the medium, at the end of the operating cycle of such a filter and requires its washing. The geometry of the calculation domain and the calculation grid are shown in Fig. 2. It is assumed that the filter is almost completely filled with quartz sand. Modelling of brine flows in the part of the filter not filled with sand was carried out on the basis of the standard turbulence model (Parshakova, et. al., 2022).

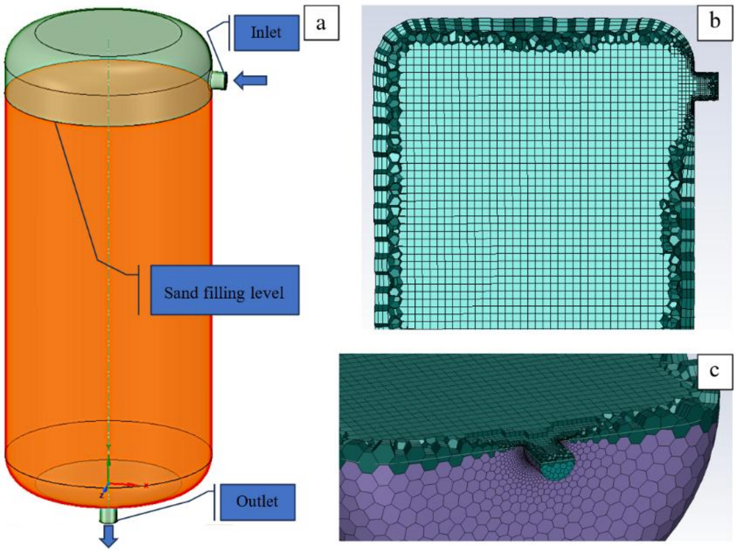

Fig. 2. Geometry of the computational domain (a) and computational grid of the proximity of the inlet (b) and outlet (c) nozzles.

The dependence of density on concentration was given by the formula:

$$\rho = \rho_0 + C,$$

where $\rho_0 = 999.993$ g/l is the density of pure water, C is salt mass concentration. As an initial state C = 0 g/l was set. At the inlet of the calculation domain, a constant operating pressure, $p_0 = 2.5$ atm, and the constant impurity concentration, C_0=300 g/l, were set. At the outlet of the design domain, normal atmospheric pressure was set. At other boundaries the condition of absence of normal velocity component was set, i.e. the boundaries were considered impermeable for the substance

Numerical modelling results. Based on the filtration model described above, a three-dimensional numerical simulation of a vertical porous column has been carried out to investigate the effects of flows on the change of porous medium properties in industrial filtration columns during filtration. The results of the calculations are shown in Figs. 3-5.

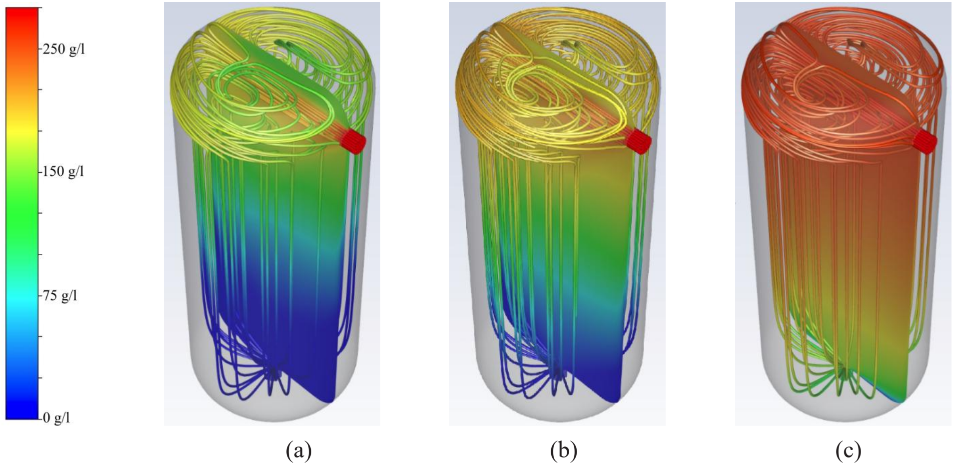

Fig. 3. Impurity concentration in the vertical section and fluid current line at different time points: (a) t = 1 hour 20 minutes, (b) t = 2 hours, (c) t = 4 hours

The filter inlet is located above the level of sand backfill in the filter. As a result, intensive turbulent fluid flows are observed in the upper part of the filter (Fig. 3), leading to brine mixing and formation of a homogeneous displacement front in the porous medium. At the same time, inside the porous medium the flow intensity is much lower and the flow structure is close to a plane-parallel flow. The average productivity of the filtration unit in the considered case was 8 m^3/h.

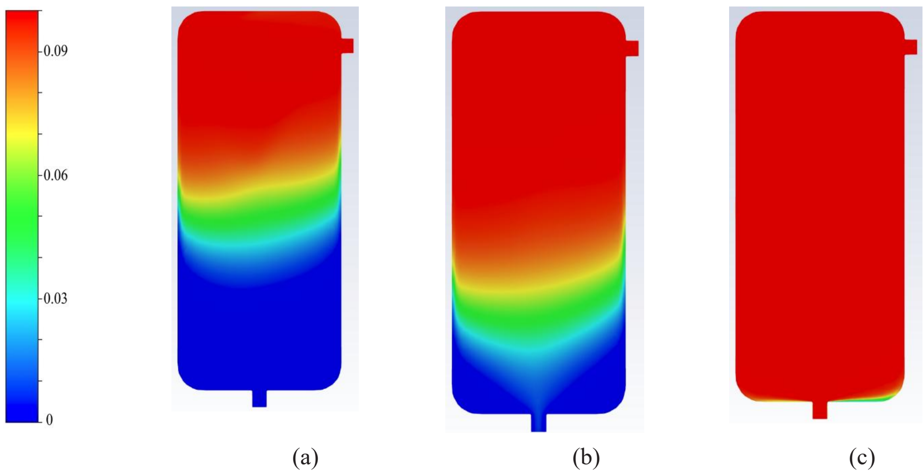

Fig. 4. Dimensionless concentration of non-mobile impurity (q) in the vertical section at different time points: (a) t = 1 hour 20 minutes, (b) t = 2 hours, (c) t = 4 hours

Calculations have shown that during filtration a significant part of the impurity passes into the non-mobile phase, i.e. settles on the skeleton of the porous medium.

At the same time, the salt concentration in the mobile phase (in the filtration flow) decreases. Fig. 4 shows dimensionless concentrations of non-mobile impurity (q) at different moments of time. As can be seen, for example, in Figs. 3, b and 4, b, the process of impurity deposition on the skeleton of the porous medium is quite intensive even in the lower part of the filter, where at the considered moment of time the salt concentration is quite low. As a result, a zone of deposited impurity accumulation is formed, which can eventually lead to a decrease in filter capacity and deterioration of cleaning efficiency. This process should be taken into account when calculating the frequency of filter washing in order to maintain its performance characteristics and to ensure the output of water with the required quality parameters. Analysing the spatial distribution of concentrations makes it possible to evaluate the filtration efficiency at different sections of the column and to predict the moment when pore blockage begins and washing is required.

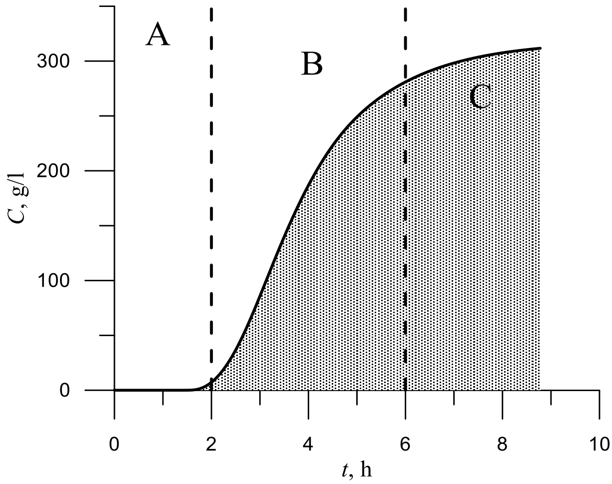

Fig. 5. Dependence of average (over the outlet section) concentration of impurity after cleaning on time

The efficiency of the considered filtration system can be estimated by the dependence of the average concentration of impurity at the filter outlet on time (Fig. 5). Modelling has shown that the filtration capacity of the system varies significantly with time. Three main stages can be distinguished: ‘A’ - filtration efficiency is high, the impurity is almost completely deposited on the skeleton of the porous medium; “B” - average filtration efficiency, there is an increase in the salt concentration at the outlet of the filtration unit; “C” - filtration efficiency decreases significantly. As a result, it can be concluded that it is necessary to wash the filter every 3 hours to remove accumulated contaminants. In this case, the time average salt concentration at the filter outlet decreases to 15 g/l.

Conclusion. Three-dimensional numerical simulation of flow in a columnar displacement array consisting of a porous medium characterised by spatial dimensions of industrial samples has been carried out. A modelling case with potassium salt as a contaminant was considered. It is assumed that the vertical column is a desalination system, as a result of its operation saturation and clogging of the pores of the medium occurs, at the end of the working cycle of such a filter requires its washing. Modelling of filtration was carried out on the basis of MIM-model taking into account density stratification. The finite volume method was used to discretise the governing equations and boundary conditions.

Three-dimensional numerical modelling of a vertical porous column was carried out on the basis of this filtration model. The filtration efficiency has been evaluated. It is shown that the column filled with fine fraction sand can be effective in re-treatment for disposal of waste water into surface water bodies without exceeding the maximum permissible concentrations. The advantage of this filtration plant is its simplicity and relatively low cost of implementation. The disadvantage is the necessity of frequent washing of the installation.

References

Agaoglu, B., Scheytt, T., Copty, N.K. Laboratory-scale experiments and numerical modeling of cosolvent flushing of multi-component NAPLs in saturated porous media // Journal of contaminant hydrology. – 2012. – Vol. 140. – pp. 80–94.

Batukhtin, A. et al. Obtaining a solution of a differential equations system for determining the heat networks retention // International Journal of Mechanical Engineering and Technology. – 2018. – V. 9(7). – P. 1300–1320.

Batukhtin, A.G., Kobylkin, M.V., Rikker, Y.O., Batukhtin, S.G. Research and analysis of the low-temperature potential of heat networks // IOP Conference Series: Materials Science and Engineering. – 2020. – V. 791(1). – P. 012039.

Bosikov, I.I., Klyuev, R.V., Khetagurov, V. N., Silaev, I. V. Comprehensive assessment of hydrodynamic processes in the Klinskoye Quarry with the use of their control methods in rock masses. // Sustainable Development of Mountain Territories. – 2023. – Vol. 15(2). – pp. 284-297. DOI: 10.21177/1998-4502-2023-15-2-284-297.

Cherkasova, T.G., Cherkasova, E.V., Tikhomirova, A.V., Gilyazidinova, N.V., Klyuev, R.V., Martyushev, N.V., Karlina, A.I., Skiba, V.Y. Study of matrix and rare elements in ash and slag waste of a thermal power plant concerning the possibility of their extraction. // Metallurgist. – 2022. – Vol. 65. – № 11-12. – pp. 1324-1330. DOI: 10.1007/s11015-022-01278-2.

Golik, V. I., Klyuev, R.V., Martyushev, N.V., Zyukin, D. A., Karlina, A.I. Prospects for return of valuable components lost in tailings of light metals ore processing. // Metallurgist. – 2023. – Vol. 67. – Nos. 1-2. – pp. 96-103. DOI: 10.1007/s11015-023-01493-5.

Golik, V.I., Klyuev, R.V., Iushkova, L.V., Brigida, V. Reuse and Mechanochemical Processing of Ore Dressing Tailings Used for Extracting Pb and Zn. // Materials. – 2023. – 16(21). – 7004. DOI 10.3390/ma16217004

Gomez, C.T., Dvorkin, J., Vanorio, T. Laboratory measurements of porosity, permeability, resistivity, and velocity on Fontainebleau sandstones Laboratory measurements on sandstones // Geophysics. – 2010. – Vol. 75. – № 6. – pp. E191–E204.

Klyuev, R.V., Bosikov, I.I., Mayer, A.V. Complex analysis of genetic features of mineral substance and technological properties of useful components of Dzhezkazgan deposit // Sustainable Development of Mountain Territories. – 2019. – Vol. 11(3). – pp. 321-330. DOI: 10.21177/1998-4502-2019-11-3-321-330.

Kobylkin, M., Rikker, Y., Batukhtin, A., Akimov, I. Measurement of fluid pressure through the pipeline wall in heat and power processes // IOP Conference Series: Earth and Environmental Science. – 2022. – V. 1070(1). – P. 012041.

Kulikova, E.Yu., Balovtsev, S.V., Skopintseva, O.V. Comprehensive assessment of geoecological risks in conducting open and underground mining. // Sustainable Development of Mountain Territories. – 2024. – vol. 16. – no. 1. – pp. 205–216. DOI: 10.21177/1998-4502-2024-16-1-205-216.

Malyukova, L.S., Martyushev, N.V., Tynchenko, V.V., Panfilova, T.A., Brigida, V. Circular Mining Wastes Management for Sustainable Production of Camellia sinensis (L.) O. Kuntze // Sustainability (Switzerland). – 2023. – 15(15) . – 11671. DOI 10.3390/su151511671

Maryshev, B.S., Khabin, M.R., Evgrafova, A.V. Identification of Transport Parameters for the Solute Filtration through Porous Media with Clogging // J. Porous Media. – 2023. – Vol. 26. – no. 31.

Nield, D.A., Bejan, A. Convection in Porous Media. – New York: Springer, 2017.

Pang, L. et al. Adsorption and transport of cadmium and rhodamine WT in pumice sand columns // New Zealand Journal of Marine and Freshwater Research. – 2004. – Vol. 38. – № 2. – pp. 367–378.

Parshakova, Y., Ivantsov, A. Dynamics of Pollution in the Hyporheic Zone during Industrial Processing Brine Discharge // Water. – 2022. – Vol. 14. – pp. 4006.

Pashkov, E.N., Martyushev N.V., Ponomarev A.V. An investigation into autobalancing devices with multireservoir system. // IOP Conference Series: Materials Science and Engineering. – 2014. – 66(1). – 012014. DOI 10.1088/1757-899X/66/1/012014

Qian, J. et al. Evaluating differences in transport behavior of sodium chloride and Brilliant Blue FCF in sand columns // Transport in Porous Media. – 2015. – Vol. 109. – № 3. – pp. 765–779.

Rolle, M., Eberhardt, C., Chiogna G., Cirpka O.A., Grathwohl P. Enhancement of dilution and transverse reactive mixing in porous media: experiments and model-based interpretation // J Contam Hydrol. – 2009. – Vol. 110, no. 3. – pp. 130–142

Yaitskaya, N.A., Khalieva A.A., Brigida V.S., Plieva M.T. Geoecological methods for assessing the coastline dynamics on the Caucasus black sea coast. // Sustainable Development of Mountain Territories. – 2024. – Vol. 16. – no. 2. – pp. 720–732. DOI: https://doi.org/10.21177/1998-4502-2024-16-2-720-732.

CONTENTS

Zh.M. Aitulova, B.O. Yessimov, T.A. Adyrbaeva, E.S. Dubinina, M.E. Kurbanbayev
SYNTHESIS OF IMPORT-SUBSTITUTING BLUE ULTRAMARINE BASED ON MINERAL RAW MATERIALS FROM UNIQUE DOMESTIC DEPOSITS..6

M.R. Aktayev, L. Akbayeva, Y. Pangaliyev, N.A. Baubek
RESEARCH OF THE CHARACTERISTICS OF UNDERGROUND AND SURFACE POLLUTION OF LAKE KISHKENSOR ON THE TERRITORY OF THE SEMIPALATINSK TEST SITE...19

G.Zh. Bulekbayeva, O.G. Kikvidze, A.U. Tabylov, A.Z. Bukayeva, N.B. Suyeuova
DEVELOPMENT OF A METHOD FOR CALCULATING THE ONE-DIMENSIONAL PROBLEM OF PLASTIC DEFORMATION OF THE DEPOSITED LAYER DURING THE RESTORATION OF FLAT SURFACES OF PARTS..34

Y.G. Gilazhov, M.Z. Muldakhmetov, A.Sh. Kanbetov, D.K. Kulbatyrov, E.B. Zhunussova
STRENGTHENING OF SOILS BASED ON OILED SOIL................................47

B.S. Ermakov, O.V. Shvetsov, S.B. Ermakov, S.A. Vologzhanina
INVESTIGATION OF THE INFLUENCE OF CAST MICROSTRUCTURE ON THE OPERABILITY OF THE CROWN OF A QUARRY EXCAVATOR...........59

Y.Kh. Kakimzhanov, K.T. Kyrgyzbay, S.M. Zhumatayev, T.A. Bazarbayeva, G.T. Kunypiyaeva
ASSESSMENT OF SOIL CONTAMINATION OF THE WEST KAZAKHSTAN REGION WITH HEAVY METALS AS A RESULT OF INDUSTRIAL ACTIVITY..72

K.Ye. Kaliyeva, Ye.D. Zhaparkulova, A.R. Vagapova, M.S. Nabiollina, L.M. Ryskulbekova
THE INFLUENCE OF CLIMATIC AND ANTHROPOGENIC FACTORS ON THE HYDROLOGICAL REGIME OF THE BASINS OF THE SHU-TALAS RIVERS..91

O.A. Kolenchukov, V.A. Fayfer, V.V. Bukhtoyarov
PREDICTION OF THE REMAINING SERVICE LIFE OF PUMPING UNIT ELEMENTS BASED ON REGULARIZATION OF RECURRENT NEURAL NETWORKS......107

A.M. Mikayilov, F.M. Jafarova, A.Z. Hajiyeva
THE GROUPING OF MILL LANDSCAPES BY DESERTIFICATION FACTORS AND RISKS......128

L.M. Mustafa, I.K. Ablakatov, B.M. Baiserikov, M.B. Ismailov, V.R. Zhumakanova
RESEARCH ON ARMOR STEEL TECHNOLOGY AND WAYS TO IMPROVE ITS MECHANICAL PROPERTIES......140

M. Nurpeisova, O. Kurmanbaev, Zh. Turegaliyeva, Zh. Nukarbekova, O.Baiturbay
INNOVATIVE TECHNOLOGIES IN THE URBAN PLANNING CADASTRE......155

Ya.N. Parshakova, A.O. Ivantsov
DEVELOPMENT OF A METHOD OF WATER TREATMENT IN THE PROCESS OF PREPARATION FOR UTILISATION OF PRODUCTION WASTE......169

B.T. Ratov, V.L. Khomenko, Z.G. Utepov, Ye.A. Koroviaka, A.A. Seidaliyev
BLADE BIT DRILLING IN KAZAKHSTAN: ACHIEVED RESULTS, UNRESOLVED ISSUES......182

G.K. Umirova, E.M. Toleubekov, S.K. Muratova, A.K. Isagalieva, Z.N. Ablesenova
THE EFFICIENCY OF A COMPLEX OF GEOPHYSICAL METHODS BY EXAMPLE OF THE ATASU ORE DISTRICT......202

O.G. Khayitov, L.S. Saidova, A.A. Umirzokov, M.A. Mutalova, N.M. Askarova
RATIONAL TECHNOLOGICAL SCHEME FOR TRANSPORTING ROCK MASS FROM DEEP QUARRY......218

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Редакторы: *Д.С. Аленов, Ж.Ш.Әден*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.02.2025.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
14,5 п.л. Тираж 300. Заказ 1.

РОО «Национальная академия наук РК»
050010, Алматы, ул. Шевченко, 28, т. 272-13-19